GLOBAL CHANGES

MIT JOINT PROGRAM ON THE SCIENCE & POLICY OF GLOBAL CHANGE

FALL 2022 NEWSLETTER

OUR RESEARCH MISSION

Advancing a sustainable, prosperous world through scientific analysis of the complex interactions among co-evolving, interconnected global systems.

The pace and complexity of global environmental change is unprecedented. Nations, regions, cities and the public and private sectors are facing increasing pressures to confront critical challenges in future food, water, energy, climate and other areas. Our integrated team of natural and social scientists produces comprehensive global and regional change projections under different environmental, economic and policy scenarios. These projections enable decision-makers in the public and private sectors to better assess impacts, and the associated costs and benefits of potential courses of action.

OUR VISION

We envision a world in which community, government and industry leaders have the insight they need to make environmentally and economically sound choices.

Toward that end, we provide a scientific foundation for strategic investment, policymaking and other decisions that advance sustainable development.

IMPACT: WHAT WE DO

The MIT Joint Program:

- Combines scientific research with risk and policy analyses to project the impacts of—and evaluate possible responses to—the many interwoven challenges of global socioeconomic, technological and environmental change.
- Communicates research findings through our website, publications, workshops and presentations around the world, as well as frequent interactions with decision-makers, media outlets, government and nongovernmental organizations, schools and communities.
- Cultivates and educates the next generation of interdisciplinary researchers with the skills to tackle ongoing and emerging complex global challenges.

IN THIS ISSUE:

SAVE THE DATE: XLV (45TH) GLOBAL CHANGE FORUM

Mar. 23–24, 2023 • Sponsor Meeting on Mar. 22

Staying the course: Achieving climate change goals in turbulent times

Attendance is by invitation only.

FALL 2022 GLOBAL CHANGES

Mark Dwortzan
Editor/Writer

Jamie Bartholomay
Designer/Copy Editor

How to plan for a just transition to a low-carbon society

Perspective: Design policies that account for economic inequalities

Climate change and inequality are among the most important issues that humankind faces in the 21st century. To address these challenges, it is essential to design and implement policies aimed at a transition towards a low-carbon society that, at the same time, helps reduce inequality among and within countries. If proposed climate change mitigation policies tend to increase the gap between rich and poor households or reduce the affordability of energy services for the poorest households, policymakers and their constituents will be more likely to reject them. The world's best chance of achieving a low-carbon economy goes hand in hand with designing policies that are effective in promoting a better distribution of benefits to all segments of society. Such socioeconomic considerations may be even more crucial to the success of low-carbon policies than technology development.

Since the Paris Agreement on climate change in 2015, most countries have introduced climate mitigation policies with wide-ranging regional and global economic implications. Of particular concern is the intersection of climate action and inequality: many studies have started to more closely examine who bears the costs of environmental and climate protection. In this context, there is an urgent need to measure the potential effect of proposed and forthcoming climate mitigation policies on individual groups within society and to analyze the impact that growing inequality may have in the fight against climate change. Research should not only focus on groups of different income levels but

Sergey Paltsev – Deputy Director, MIT Joint Program

also consider other important social and cultural characteristics that might be impacted differently such as race/ethnicity, family size, gender, geographical location (rural/urban) or education.

At the MIT Joint Program on the Science and Policy of Global Change, we continue to address different aspects of a just transition to a low-carbon economy. To enhance our outreach to decision-makers and the general public on this issue, we recently released a Youtube video (produced together with the Basque Center for Climate Change). The video illustrates key concepts of our study that evaluates a sweet spot at which a national carbon policy can both avoid inflicting economic harm on lower-income Americans at the household level and improve economic efficiency at the national level. Our analysis indicates that policymakers can mitigate negative distributional impacts with positive synergies on efficiency.

—Sergey Paltsev, Deputy Director

Perspective: Identify risks, enable responses in vulnerable communities

Communities around the world are expected to face multiple physical and economic stressors over the coming decades amid a rapidly changing climate and accelerated transition to low-carbon energy sources. The vulnerability or resilience of communities—their ability to successfully cope with stressors—will vary. Poorer communities have fewer financial resources at their disposal, and minority communities often do not receive sufficient attention or support. The overall health of a community and access to health care also results in varying ability to cope with stressors, from exposure to heat or pollution to rising prices and unemployment.

Among the major challenges that we face in identifying and addressing the needs of marginalized communities is to collect and combine data that accurately identify environmental and economic stressors, and enable decision-makers to quantify overall risk and set priorities.

First, the needed data is often difficult to find and access. Much of it is disaggregated across multiple agencies, universities and research groups, and presented at different geographical scales in varying formats. Second, combining these data and creating metrics to address "overall risk" is no easy task. Third, gathering the data and projections necessary to understand environmental change and a community's vulnerabilities is itself a significant undertaking. Finally, recruiting experts, evaluating available data and projections, and determining vulnerable infrastructure, populations and economic activity even at a very low level can require hundreds of thousands of dollars, if not many millions.

What's needed is an efficient, low-cost, screening-level assessment tool that can identify

Adam Schlosser – Deputy Director, MIT Joint Program

"hot spots" and prioritize where resources and efforts can be most effectively deployed. To that end, researchers at the MIT Joint Program have released and continue to develop an extensive collection of data, constructed metrics, and an interactive, visualization platform that allows U.S. citizens, scientists, communities, states and the federal government to identify particularly vulnerable regions, populations, infrastructure and resources.

We developed the platform with the flexibility to change or add to the data, models and metrics in response to feedback from the research community, government and private stakeholders as well as citizen scientists. Such feedback can point to areas where new data or advanced prediction models are needed. From this screening-level assessment, hot spots of risk can be identified that point to deeper diagnoses of risks and their solutions at a more granular and detailed level. Identifying the most vulnerable locations provides an opportunity to intervene before serious, irreversible and costly consequences ensue.

—Adam Schlosser, Deputy Director

MIT Joint Program News Releases:
Latest research developments and their implications

MIT Joint Program in the Media:
Latest coverage of our research

The following summaries are listed by primary research focus area, but may span multiple research focus areas. For more information on Joint Program research, please visit our website at globalchange.mit.edu.

Earth Systems

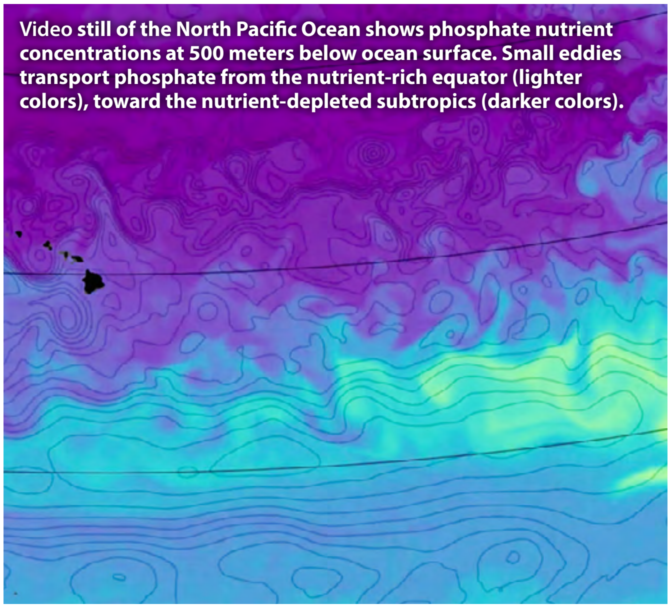
Changes and risks to interconnected land, ocean, atmosphere and biosphere systems

Small eddies play a big role in feeding ocean microbes

Swirling waters replenish nutrients in open ocean, a new study finds, and could mitigate some climate change effects (MIT News)

Ocean eddies appear to be an important source of nutrients in subtropical gyres. Their replenishing effect, which the researchers call a "nutrient relay," helps maintain populations of phytoplankton, which play a central role in the ocean's ability to sequester carbon from the atmosphere. While climate models tend to project a decline in the ocean's ability to sequester carbon over the coming decades, this "nutrient relay" could help sustain carbon storage over the subtropical oceans.

Different parts of the planet warm more quickly than others. That doesn't mean climate change isn't happening. (Climate Feedbacks)
MIT Joint Program Deputy Director C. Adam Schlosser helps explain regional variations in warming



Video still of the North Pacific Ocean shows phosphate nutrient concentrations at 500 meters below ocean surface. Small eddies transport phosphate from the nutrient-rich equator (lighter colors), toward the nutrient-depleted subtropics (darker colors).

Will climate feedback loops push us past a "point of no return"?

Tripping the Earth's climate feedback loops could bring us rapid warming that would be hugely damaging in the near term. But over the longer term, our planet can regulate even truly gigantic changes to the atmosphere. (MIT Climate Portal)

Is it possible that climate system feedback loops could send us past a point of no return—a tipping point where humans no longer have the power to slow climate change? Not exactly, says MIT Joint Program Research Scientist Andrei Sokolov, an expert on climate sensitivity. Over longer time periods, he says, the Earth will balance itself out through corrective measures, such as the ocean absorbing carbon dioxide from the air. In the short term, though, the warming effects of feedback loops may make our planet a decidedly unpleasant place to live.

Managed Resources

Changes and risks to managed agriculture, water, land and energy systems

New J-WAFS-led project combats food insecurity

The Jameel Index for Food Trade and Vulnerability — a project supported by Community Jameel — will study the implications of climate change on food security as they relate to trade (J-WAFS)

The Abdul Latif Jameel Water and Food Systems Lab (J-WAFS) at MIT announced a new research project to tackle one of the most urgent crises facing the planet: food insecurity. Approximately 276 million people worldwide are severely food insecure, and more than half a million face famine conditions. To better understand and analyze food security, this three-year project will develop a comprehensive index assessing countries' food security vulnerability.

Future renewable diesel plant will turn food crops into fuel (National Observer)
MIT Joint Program's John Reilly touts grasses as a more sustainable biofuel alternative than food crops

MANAGED RESOURCES - CONT'D

Tapping the land for climate solutions

Workshop explores sustainable, equitable pathways to transform agriculture, forestry and other land uses into net carbon sinks

To draw down enough carbon dioxide to make a significant contribution to global efforts to combat climate change, nature-based solutions will require a massive deployment of agriculture, forestry and other land-use (AFOLU) practices. At the same time, these solutions must be sustainable and equitable. To help advance AFOLU best practices and identify potential research collaborations, the MIT Joint Program co-organized a workshop at Oxford University and on Zoom in September.

Infrastructure & Investment

Physical and transition risk; adaptation and resilience to climate change and extreme events

An oil rig in the Santa Barbara Channel

Stranded assets could exact steep costs on fossil energy producers and investors

Study estimates potential losses by 2050 amid low-carbon energy transition

An MIT Joint Program-led study in the journal *Climate Change Economics* estimates the current global asset value of untapped fossil fuels through 2050 under four increasingly ambitious climate-policy scenarios. The study finds that the global net present value of untapped fossil fuel output through 2050 relative to a reference "No Policy" scenario ranges from $21.5 trillion to $30.6 trillion. For untapped coal power generation only, the range is $1.3 to $2.3 trillion.

Hacking Climate Change (Technology Review)

MIT is all about making the world a better place. This special report on the Climate Grand Challenges initiative looks at how the Institute's problem solvers are stepping up to help save the planet from the devastating effects of global warming.

Extreme heat in the US, Europe and China is slamming economies around the world—and making inflation worse (Fortune, Yahoo!)

Extreme events are contributing to high prices, says MIT Joint Program Deputy Director Sergey Paltsev

Losses from fossil fuel stranded assets 'could reach $30.6tn' (Net Zero Investor)

A new study has estimated that the global net present value (NPV) of stranded assets in fossil fuels could be $30.6tn under a scenario where net zero is achieved by 2050

COMMENTARY **Extreme heat kills inequitably: Reflective pavements can help, but city action is required (The Hill)**

Commentary cites Joint Program Report on the climate mitigation potential of U.S. urban infrastructure albedo enhancement

Energy Transition

National and global projections of the future energy mix; prospects for different sectors and technologies

Affordable direct air capture: myth or reality?

MIT seminar explores economic feasibility of technology that could play a key role in the energy transition

At a campus seminar co-hosted in May by the MIT Joint Program and MIT Laboratory for Aviation and the Environment, MIT Energy Initiative (MITEI) Senior Engineer Howard Herzog, a pioneer in carbon capture research, evaluated the technical, logistical and financial challenges of deploying DAC at scale. Harvard University Professor of Applied Physics David Keith, founder of Carbon Engineering, shared his view on those challenges and on how DAC could play a substantial role in advancing net-zero economies.

Can electric vehicles decarbonize transportation? (UNFCCC)

In the United Nations Climate blog Electric Future, MIT Joint Program Deputy Director Sergey Paltsev highlights challenges in making EVs truly emissions-free

Are EVs driving towards greener world or uncertainty? (TRENDS MENA)

Recent studies suggest that electric vehicles may not eliminate all emissions even by 2050, particularly those related to mining and battery production

US solar and wind projects stalled in Q2. What happened? (Canary Media)

The Auxin Solar tariff investigation and uncertainties around tax incentives tanked progress, according to a new American Clean Power report

BEVs and FCEVs can meet Paris Agreement goals (Power Electronics News)

Policymakers and manufacturers are working toward building new technologies to reduce the carbon footprint of cars

Are electric vehicles definitely better for the climate than gas-powered cars?

Yes: although electric cars' batteries make them more carbon-intensive to manufacture than gas cars, they more than make up for it by driving much cleaner under nearly any conditions.

Although many fully electric vehicles (EVs) carry "zero emissions" badges, this claim is not quite true. Battery-electric cars may not emit greenhouse gases from their tailpipes, but some emissions are created in the process of building and charging the vehicles. Nevertheless, says MIT Joint Program Deputy Director Sergey Paltsev, electric vehicles are clearly a lower-emissions option than cars with internal combustion engines. Over the course of their driving lifetimes, EVs will create fewer carbon emissions than gasoline-burning cars under nearly any conditions.


Climeworks direct air carbon capture plant in Iceland.

Policy Scenarios

Environmental and economic change under different climate, air pollution, and economic policies

Six leading models agree: Rapid decarbonization of power, transportation sectors key to a successful energy transition

Study lays out roadmap to reach 2030 U.S. climate target to reduce greenhouse gas emissions by at least 50 percent (Coverage: Washington Post, E&E News)

A study in the journal *Science* co-authored by MIT Joint Program Co-Director Emeritus John Reilly provides a clear and concise roadmap on how to achieve the 2030 U.S. climate goal that its coauthors say is technologically and economically feasible to implement, and delivers multiple long-term benefits. Based on the consensus of six leading energy/economic models, the study provides the first detailed roadmap for how the U.S. can reach its 50-percent greenhouse gas emissions-reduction target by 2030.

Pricing carbon, valuing people

New video shows how U.S. climate policies can be designed to enable a just energy transition

An MIT Joint Program study published in *Energy Economics* in 2022 shows how U.S. climate policies can be designed to cut carbon emissions without inflicting economic harm on low-income households and the nation as a whole. To illustrate an earlier Joint Program news story about the study, the Basque Center for Climate Change produced this new video.

Coordinating climate and air-quality policies to improve public health

New tool pinpoints policy combinations that maximize health benefits

While climate policies can simultaneously help mitigate climate change and improve air quality, their public health benefits may vary widely. Those benefits can be maximized, however, through a prudent combination of climate and air-quality policies. In a study in the journal *Geoscientific Model Development,* Joint Program and MIT collaborators introduce a tool that can be used to estimate the likely air-quality and health outcomes of a wide range of climate and air-quality policies at regional, sectoral and fuel-based levels.

The climate bill won't stop global warming. But it will clean the air. (Washington Post)
MIT's Noelle Selin and John Sterman comment on potential air quality and climate benefits

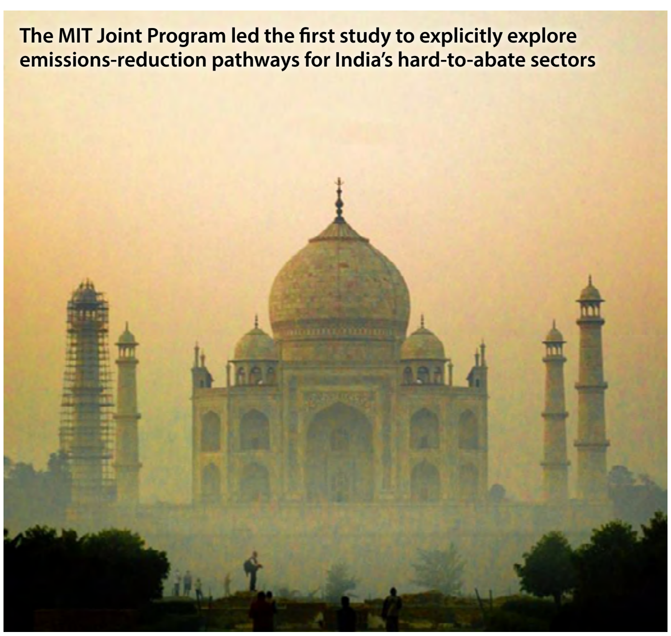
COMMENTARY **Fighting climate change in a fragmented world (The Hill)**
Why it's important for U.S. scientists to sustain engagement with their Chinese and Russian peers

COMMENTARY **Here's how to meet Biden's 2030 climate goals and dramatically cut greenhouse gas emissions – with today's technology (The Conversation)**
MIT Joint Program Co-Director Emeritus John Reilly lays out 'doable and affordable' policy roadmap (Republished in *MarketWatch* and *Fast Company*)


Being outdoors can be hazardous to your health in Anyang City, Henan Province, China

Regional Analysis

Science and policy studies at subnational, national and multinational levels


The MIT Joint Program led the first study to explicitly explore emissions-reduction pathways for India's hard-to-abate sectors

Getting the carbon out of India's heavy industries

Study highlights pathways to cut emissions, lower climate and health risks

A new study in the journal *Energy Economics* led by MIT Joint Program researchers is the first to explicitly explore emissions-reduction pathways for India's hard-to-abate sectors. In such sectors, which involve energy-intensive industrial processes (production of iron and steel; nonferrous metals such as copper, aluminum, and zinc; cement; and chemicals), decarbonization options are limited and more expensive than in other sectors.

Water Crisis in South Africa: Causes, Effects, And Solutions (Earth.org)
Report cites MIT Joint Program study projecting significant water-supply risks by 2050

Multi-Sector Dynamics

Potential tipping points and transition states of Earth and human systems

AGU Fall Meeting frames science as engine of a better future

MIT Joint Program presentations showcase tools and pathways to assess and alleviate regional and global risk

Organized around the theme "Science Leads the Future," this year's AGU Fall Meeting will take place in Chicago and online on December 12 - 16. Among those researchers will be 15 co-authors of oral and poster presentations, and conveners of conference sessions, who are core members or faculty affiliates of the MIT Joint Program. Categorized by primary research focus area, their hyperlinked presentations and sessions highlight tools and pathways to assess and reduce regional and global risk.

AGU Fall Meeting Central Exhibit Hall

Modeling Systems

Our state-of-the-art models and analytical methods project global and regional changes and potential risks under different policy scenarios

MIT is creating a digital twin of the Earth to help model climate change (WBUR)

To put global climate modeling at the fingertips of local decision-makers, some scientists think it's time to rethink the system from scratch. Five Joint Program-affiliated researchers will help advance an MIT Climate Grand Challenges flagship project to do just that.

New Research Projects

Global Outlook for Fusion Energy Deployment

Sponsor: Eni (via MITEI)

Duration: 16 months

Leader: Sergey Paltsev

We will assess the threshold cost and performance parameters that fusion technology must deliver to become a substantial contributor to decarbonization at the global scale. This project will determine the parameters for fusion viability and identify which of these parameters are most important for the successful deployment of fusion energy at scale. Even if fusion power is available for deployment in all countries, the expectation is that deployment will be heterogenous due to the availability of other low-carbon energy resources, population density, grid infrastructure, etc. Therefore, we will examine the extent of deployment of fusion power plants in all regions represented in the MIT Economic Projection and Policy Analysis (EPPA) model. We will assess how the timing of fusion commercialization will impact its extent of deployment and overall mitigation pathways.

MIT Climate Grand Challenges Flagship Project: Bringing computation to the climate challenge

The development of a digital twin of the Earth that can harness more data than ever before to increase the accuracy of climate models and make them more useful for communities and other stakeholders

Sponsor: MIT

Duration: 1 year

Leaders: Rafaele Ferrari, Noelle Selin

MIT Joint Program-affiliated contributors: Noelle Selin, C. Adam Schlosser, Arlene Fiore, Christopher Knittel, John Marshall

Anthropogenic climate change will reshape our world, but we lack sufficiently accurate and useful projections of how. The goal of this grand challenge is to provide accurate and actionable scientific information to decision-makers to inform the most effective mitigation and adaptation strategies. We envision a novel platform that leapfrogs existing climate decision support tools by leveraging advances in computational and data sciences to improve the accuracy

NEW RESEARCH PROJECTS - CONT'D

of climate models, quantify their uncertainty, and addresses the trade-off between performance and computation time with attention to industry and government stakeholder needs. First, we will develop a digital twin of the Earth that harnesses more data than ever before to reduce and quantify uncertainties in climate projections. To serve the needs of stakeholders, we will develop emulators of the digital twin tailored to maintain the highest possible accuracy in predicting specific variables, like droughts, floods or heat waves, while still being easy and fast to run.

MIT Climate Grand Challenges Flagship Project: Preparing for a new world of weather and climate extremes

A scalable toolkit to help vulnerable populations face the new reality of intensifying climate events and accelerate the transition to low-carbon resources

Sponsor: MIT

Duration: 1 year

Leaders: Kerry Emanuel, Paul O'Gorman, Miho Mazereeuw

Joint Program-affiliated contributors: C. Adam Schlosser, Xiang Gao, Kenneth Strzepek, Kerry Emanuel, Paul O'Gorman, Timothy Cronin

Climate change is intensifying extreme weather and climate events, such as the unprecedented heatwave in western North America in 2021 and rainfall from Hurricane Harvey in 2017. These devastating events are becoming more intense globally, but we do not adequately know the changing risks for specific regions and communities, or how changing extremes will affect the wider use of wind, solar and hydroelectric energy that is needed to limit future greenhouse gas emissions. Our grand challenge will address these key gaps in knowledge by making improvements in the science and prediction of extremes and their effects on our energy systems. Based on the improved predictions of extremes, we will build a scalable toolkit, initially focused on cities in the United States and Africa, for communities and stakeholders to prepare and adapt. Our team brings together experts in climate science, engineering, design and machine learning at MIT with external partners to provide the greatest benefit to communities, municipalities and industry.

MIT Climate Grand Challenges Flagship Project: Reinventing climate change adaptation with the Climate Resilience Early Warning System (CREWSnet)

Cutting-edge forecasting technology that boosts climate resilience by empowering underserved communities to interpret local risk, minimize loss and plan for their futures

Sponsor: MIT

Duration: 1 year

Leaders: Elfatih Eltahir, John Aldridge, Deborah Campbell

Joint Program-affiliated contributors: Ronald Prinn, C. Adam Schlosser, Sergey Paltsev, Anne Slinn, Elfatih Eltahir, Kerry Emanuel

Global climate change is exacting a heavy toll on vulnerable populations worldwide. CREWSnet will integrate state-of-the-art climate science, impact modeling and accessible decision support tools within an established humanitarian and social development environment. Starting with the most climate-vulnerable areas of Bangladesh, our vision is to build and demonstrate the CREWSnet forecasting system, development model, and intervention tools within five years, with the intent to expand and transition this capability for sustainment as a global public good. To achieve true impact in climate adaptation, the solutions created must be linked to those in need by organizations equally committed to social and humanitarian progress. BRAC, a project partner headquartered in Dhaka, is widely admired for its vision, durability, and scale, and brings inclusive and evidence-based economic development, climate resilience and humanitarian assistance programs to more than 100 million people globally.

In Memoriam: Richard Eckaus

Professor Emeritus Richard "Dick" Eckaus, who specialized in development economics, dies at 96

Deeply respected advisor, educator and mentor was a founding member of the MIT Joint Program on the Science and Policy of Global Change and committed to helping others rise out of poverty (MIT Economics)

Eckaus was . . . deeply interested in economic aspects of energy and environment, and in 1991 was instrumental in the formation of the MIT Joint Program on the Science and Policy of Global Change, a program that integrates the natural and social sciences in analysis of global climate threat. As Joint Program co-founder Henry Jacoby observes, "Dick provided crucial ideas as to how that kind of interdisciplinary work might be done at MIT. He was already 65 at the time, and continued for three decades to be active in guiding the research and analysis." **Read more.**

Joint Program Reports

359. A Tool for Air Pollution Scenarios (TAPS v1.0) to Facilitate Global, Long-term, and Flexible Study of Climate and Air Quality Policies

360. The MIT EPPA7: A Multisectoral Dynamic Model for Energy, Economic, and Climate Scenario Analysis

361. Assessing Compounding Risks Across Multiple Systems and Sectors: A Socio-Environmental Systems Risk-Triage Approach

362. SEBALIGEE v2: Global Evapotranspiration Estimation Replacing Hot/Cold Pixels with Machine Learning

Peer-Reviewed Studies

Actions for reducing US emissions at least 50% by 2030 (*Science*)

Economic Dispatch Considering Hourly Capacity Allocation with a Variable Renewable and Hydro-Based Generation Portfolio (*Energy & Power Eng*)

A Tool for Air Pollution Scenarios (TAPS v1.0) to enable global, long-term, and flexible study of climate and air quality policies (*Geosci Model Dev*)

When and How to Use Economy-Wide Models for Environmental Policy Analysis (*Annual Rev of Res Econ*)

A nutrient relay sustains subtropical ocean productivity (*PNAS*)

Incorporating dynamic crop growth processes and management practices into a terrestrial biosphere model for simulating crop production in the United States: Toward a unified modeling framework (*Ag & Forest Meteorol*)

The plastic intensity of industries in the USA: The devil wears plastic (*Environ Model & Assess*)

Modelling the growth of atmospheric nitrous oxide using a global hierarchical inversion (*Atmos Chem Phys*)

Comment on 'Egypt's water budget deficit and suggested mitigation policies for the Grand Ethiopian Renaissance Dam filling scenarios' (*Environ Res Lett*)

Uncertainty analysis in multi-sector systems: Considerations for risk analysis, projection, and planning for complex systems (*Earth's Future*)

A multisectoral dynamic model for energy, economic and climate scenario analysis (*Low Carbon Econ*)

Economic analysis of the hard-to-abate sectors in India (*Energy Econ*)

Attribution of space-time variability in global-ocean dissolved organic carbon (*Global Biogeochem Cycles*)

Projections of HFC emissions and the resulting global warming based on recent trends in observed abundances and current policies (*Atmos Chem Phys*)

An economy-wide framework for assessing the stranded assets of the energy production sector under climate policies (*Clim Change Econ*)

Milestones

Jennifer Morris (MIT Joint Program, MIT Energy Initiative) promoted from Research Scientist to Principal Research Scientist.

Much of her research focuses on complex adaptive systems, energy transitions and economic development pathways as well as uncertainty and decision-making. Based at the Joint Program since 2007, she is a key contributor to the development of the MIT Integrated Global System Modeling (IGSM) framework, focusing on the human system component, the Economic Projection and Policy Analysis (EPPA) model. With this modeling framework, she develops integrated economic and climate scenarios, generates large ensembles, analyzes policy impacts, explores technology and mitigation pathways and transitions, and examines multi-sector dynamics. Her uncertainty-related work involves quantifying key uncertainties and applying different methodological approaches to models in order to formally represent such uncertainties and explore how they impact near-term decisions. A key focus is evaluating risks to different investment options in energy and water and identifying those that are robust to potential risks. She holds a PhD in Engineering Systems and an MS in Technology and Policy from MIT.

Sebastian Eastham (MIT Joint Program, MIT Center for Global Change Science) promoted from Research Scientist to Principal Research Scientist, and welcomed as a new core member of the MIT Joint Program.

Previously based at the MIT Laboratory for Aviation and the Environment (2017 to 2022), his work is focused on understanding, quantifying and mitigating the environmental impacts of anthropogenic emissions using computational models and Earth observations. This includes estimates of the air quality impacts of automobile emissions ("Dieselgate"), an evaluation of climate impacts of supersonic aviation, new insights into the atmospheric chemistry of aircraft emissions, exploration of the possible unintended consequences of geoengineering, and broad research into the formation and effects of aircraft condensation trails ("contrails"). Central to his work is the development and application of state-of-the-science computational models of the Earth system with the aim of exploiting near real-time data, delivering novel capabilities in environmental impact assessment and mitigation. He holds a PhD in Aeronautical and Astronautical Engineering from MIT.

This article is based on information provided by the MIT Energy Initiative and Laboratory for Aviation and the Environment.

Photo Credits:

p 3: © Oliver Jahn, study co-author

p 4(a): © Antoine Beyeler | Dreamstime

p 4(b): © dirtsailor2003 | Flickr

p 5: © Arni Saeberg | Climeworks

p 6(a): © V.T. Polywoda | Flickr

p 6(b): © Vishnudeep Dixit | Pexels

p 7: © AGU

Cover:
(a) see p 4(a)
(b) see p 4(b)
(c) see p 6(a)

MIT JOINT PROGRAM ON THE SCIENCE AND POLICY of GLOBAL CHANGE

Our work is funded by an international partnership of government, industry and foundation sponsors, and by private donations. Our sponsor consortium provides the long-term substantial commitment needed to support our dedicated and specialized staff, and to realize a coordinated integrated research effort.

Federal Sponsors

- U.S. Congressional Budget Office [CBO]
- Environmental Protection Agency [EPA]
- National Science Foundation [NSF]
- U.S. Department of Energy [DOE]
- Federal Aviation Administration [FAA]
- National Aeronautics & Space Administration [NASA]

Program Sponsors

- Biogen
- Chevron
- ConocoPhillips
- Dow Chemical
- Exelon
- ExxonMobil
- J-Power
- Manulife
- Murphy Oil
- Norwegian Ministry of Petroleum & Energy
- Novartis
- Shell
- TotalEnergies
- Vetlesen Foundation
- Wellington Management

Project Contributors

- Bank of Canada
- Chevron
- Earle A Killian III and Waidy Lee MIT Seed Fund
- Electric Power Research Institute
- Eni
- ExxonMobil
- International Energy Agency Gas & Oil Technology Collaboration Programme
- MITEI Future Energy Systems Center consortium
- MIT Int'l Science and Policy Initiatives (MISTI) Imperial College Seed Fund
- MIT Office of Sustainability
- MIT Office of the Vice President of Research
- Morgan Stanley
- Shell
- TotalEnergies

Global Changes is published biannually by the MIT Joint Program on the Science and Policy of Global Change, and is made available to the public one month after its release to our program membership.

For inquiries, permission to reproduce, or subscription to future newsletters, please email **globalchange@mit.edu**

Massachusetts Institute of Technology
77 Massachusetts Ave., E19–411
Cambridge, MA 02139 USA

T (617) 253–7492 **F** (617) 253–9845
globalchange@mit.edu
http://globalchange.mit.edu